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Direct laser recording on amorphous silicon film

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Abstract

Results of direct laser recording on amorphous silicon film by laser with wavelength λ= 532 nm and Blu Ray single mode laser diode with λ= 405 nm are presented. Measurements of a-silicon film transmission spectrum before and after exposure by focused laser beam demonstrates its changing. It proves the refractive index changing of recording layer under laser radiation interaction and transformation of amorphous silicon to crystalline silicon under laser radiation interaction. Measurement of recorded relief shows that under laser radiation interaction to a-silicon layer relief depth is about 30-100 nm. Microstructures with a size of 5–7 μm are recorded by 120mW single mode Blu Ray laser diode with λ= 405 nm. Use of Blu Ray laser diodes for recording on amorphous silicon film opens opportunities to design compact Laser Writing System for diffractive structures fabrication and interference lithography.

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Keywords: direct laser recording; amorphous silicon film; Blu Ray laser ;

1. Introduction

Direct laser recording on amorphous silicon film is attractive for diffractive structures recording without wet chemical processing and it bring new possibilities of diffractive structures fabrication with the use of laser writing device [Poleshchuk et al. (2010)] . Example of widely used simple diffractive structures is antireflective coatings based on subwave gratings [Schopf et al. (1998)] with a period of approximately half of the light wavelength. The use of high-speed scanning systems of interference lithography (SILs) [Poleshchuk et al. (2005); Kutanov & Snimshikov (2011)] forming diffractive structures by consecutive writing of moderate-size fragments or cells is expecting to assist in solving the problem of deposition of antireflective diffractive coatings onto large-size surfaces

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of solar panels. Early, we demonstrated direct laser recording of dot holograms on amorphous silicon film by pulsed UV laser with λ= 355 nm [Kutanov & Snimshikov (2011)]. This paper present results of research on direct laser recording on amorphous silicon film using green laser (λ= 532 nm) and single mode laser diode with λ= 405 nm.

2. Measurement of absorption spectrum for amorphous silicon film on glass substrate

Two-beam spectrophotometer PYE UNICAM is used to measure spectrum of absorption for amorphous silicon layer on glass substrate. The spectrums of amorphous silicon film absorption depend on wavelength for different thickness are shown on (Fig. 1).

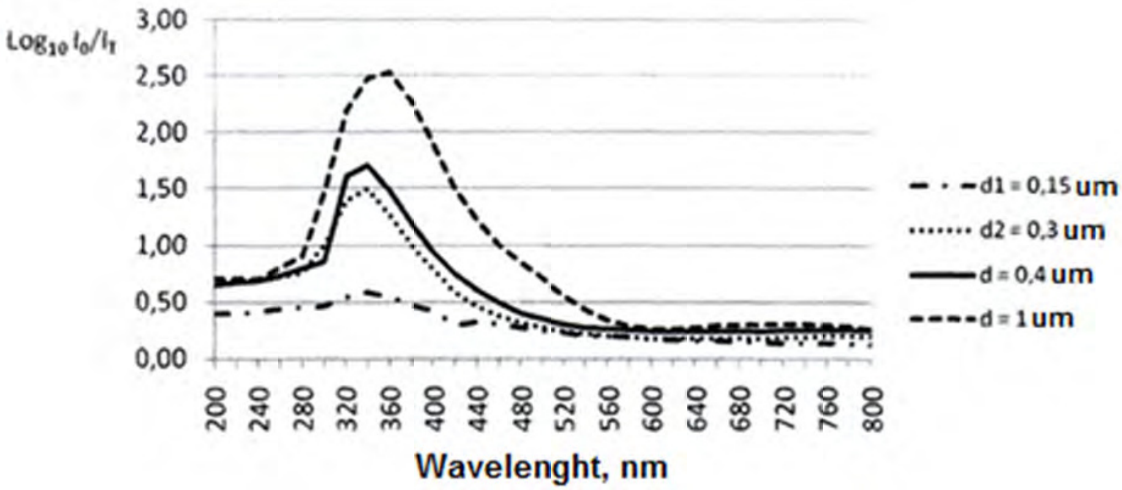

Fig. 1. Absorption spectrums of amorphous silicon film depend on wavelength for different thickness (d1=0.15μm, d2=0.3 μm, d3= 0.4 μm and d4= 1 μm)

One can see that maximum of light absorption for amorphous silicon layer is for wavelength range of 340…360 nm. Early, we demonstrated possibility of dot holograms recording on a-silicon film using pulse UV-laser with λ= 355 nm [Kutanov & Snimshikov (2011)]. Fig. 2 shows photo of grating, recorded on amorphous silicon film on glass substrate by pulse UV-laser with λ= 355 nm with pulse energy 0.10 μJ.

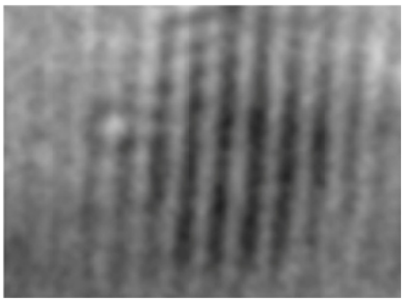

Fig. 2. Photo of the surface relief of dot hologram recorded by pulse UV-laser (λ= 355 nm) on *a*-Si film

For different applications it is interesting to explore direct laser recording on a-silicon film for exposing laser radiation with λ= 405 nm (Blu Ray laser diode) and with green laser (λ= 532 nm) on Polar Coordinate Laser Pattern Generator for Fabrication of Diffractive Optical Elements with Arbitrary Structure [Poleshchuk et al. (1999)] . Measurements of a-silicon film absorption spectrum before (red curve) and after (blue curve) exposure by focused laser radiation (λ= 532 nm) shown on Fig.3 demonstrates that after exposure by focused laser radiation the absorption spectrum is changing. It proves the refractive index changing for recording medium after interaction with laser radiation.

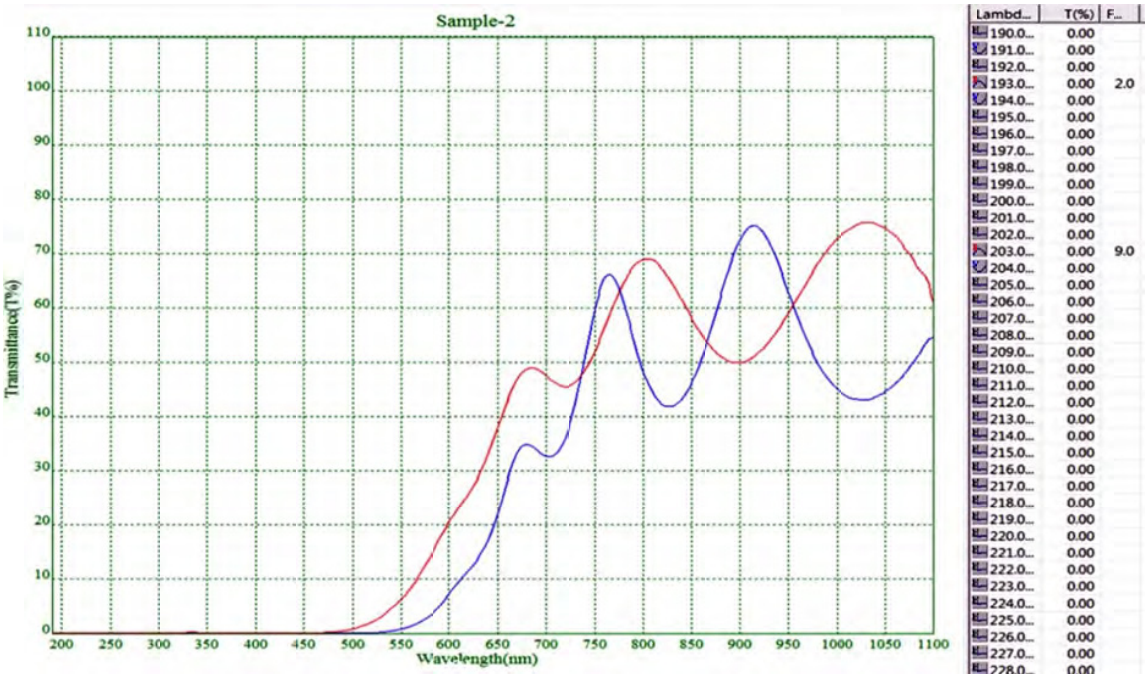

Fig. 3. Measurements of a-silicon film absorption spectrum before (red curve) and after (blue curve) exposure by focused laser radiation (λ= 532 nm)

3. Experiment on direct recording on amorphous silicon by single mode Blu Ray laser diode λ= 405nm

For direct recording on amorphous silicon Mitsubishi 120mW single mode Blu Ray laser diode was used**.** Laser beam is collimated by aspheric lens after laser diode and then it focused by micro objective to recording media. Computer controls laser pulse duration and their frequency. Fig. 4 shows photo taken from microscope in transmitted light for spots(a) and lines(b) recorded by single mode Blu Ray laser diode on *a*-Si film on glass substrate.

In order to measure the depth of the relief recording on amorphous silicon film sample was performed on the interference scanning white light microscope VLI in reflection mode. Measurement of recorded relief on Fig.5 showed that under the interaction of laser radiation to the amorphous silicon film the relief formed with height 30 - 100 nm.

The drawback of single mode laser diode used for experiments was a short length of coherence and it dependence from output radiation power. It was difficult to record by Blu Ray laser dot holograms for fabrication of master matrix hologram for embossing holograms reproduction. Therefore, it will be useful to have Blu Ray laser diode with the greater length of coherence.

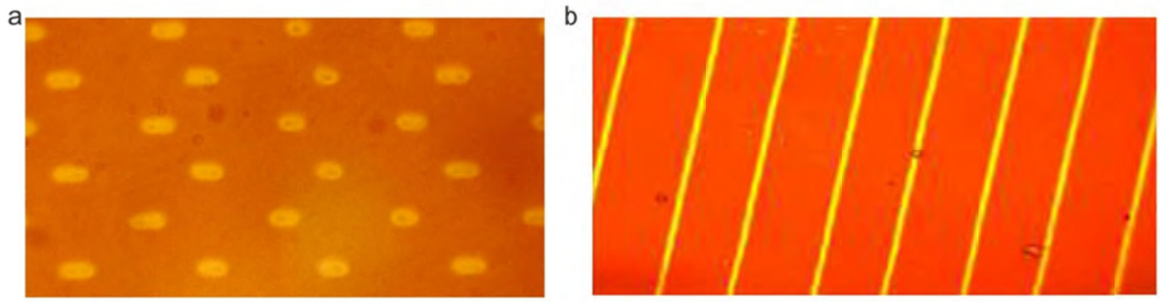

Fig. 4. Photos of spots(a) and lines(b) recorded on amorphous silicon by single mode laser diode with λ= 405 nm

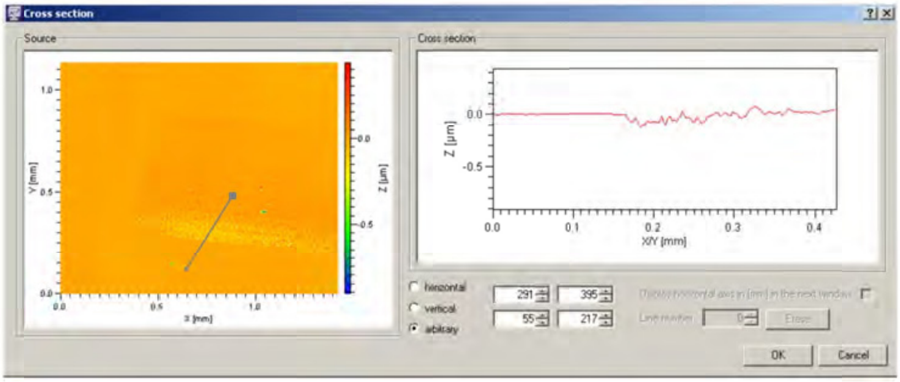

Fig. 5. Measuring relief formation under focused laser (λ= 405 nm) beam interaction to a-silicon layer with volume increasing. Relief amplitude is ~100 nm.

4. Conclusions

It's shown that under interaction of *a*-Si film by focused laser beam the local crystallization appears and relief is forms with depth ~30-100 nm. Measurements of absorption spectrum demonstrated that amorphous silicon layer's reflex index is changing after exposure by focused laser beam. It makes attractive use of direct laser recording on amorphous silicon for security applications. Direct laser recording on amorphous silicon by single mode Blu Ray laser diode λ= 405nm was demonstrated. Use of single mode Blu Ray laser diodes opens opportunities to design compact laser device for diffractive structures fabrication for different application.

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